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(71) Applicants *(for all designated States except US)*: HASBRO INTERNATIONAL, INC. [US/US]; 1027 Newport Avenue, Pawtucket, RI 02862-1059 (US). C21 TECHNOLOGIES LIMITED [GB/GB]; 55 Fitzjohns Avenue, London NW3 6PH (GB).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: WILES, Ian, Michael [GB/GB]; IPR Technology, 48 Sibelius Close, Basingstoke, Hants RG22 4HU (GB). STEELE, David [GB/GB]; Steele Microsystems, Daventry Road, Newnham, Northants NN11 6HF (GB). BROWN, Stuart, David [GB/GB]; 2 Long Furlong, Haddenham, Aylesbury, Bucks HP17 8DQ (GB). JESSOP, Richard, Vernon [GB/GB]; C21 Technologies Limited, 55 Fitzjohns Avenue, London NW3 6PH (GB).

(74) Agent: GILL JENNINGS & EVERY; Broadgate House, 7 Eldon Street, London EC2M 7LH (GB).

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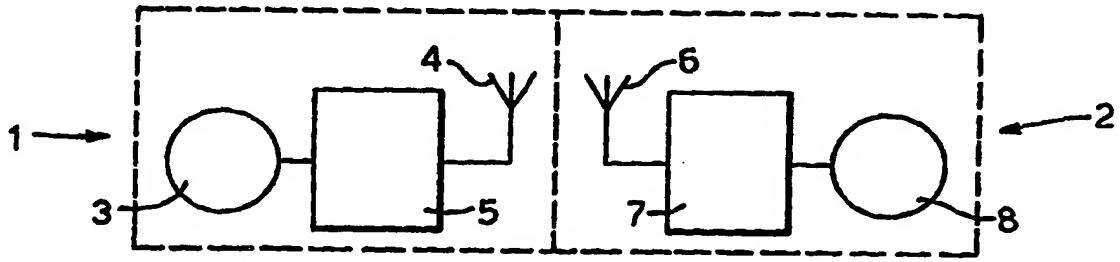

(57) Abstract

Electronic toy or game playing apparatus comprises one or more transmit aerials (4) associated with a playing region. One or more playing pieces each contain a transponder (2) and are movable within the playing region. An oscillator (3) provides an input signal to the or each aerial (4) at a predetermined input oscillation frequency. A monitor (5) is provided for simultaneously monitoring the power output by the aerial (4). Each transponder includes a receive area (6) to receive signals from the selected transmit aerial (4) and a circuit (7, 8) which draws power from the transmit aerial (4) in a variable manner thereby modulating the power output by the transmit aerial (4) in the same variable manner, whereby the presence of a piece in the playing region can be determined.

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ELECTRONIC TOY OR GAME PLAYING APPARATUS

The present invention relates to electronic game apparatus, in which the presence and optionally identity of playing pieces is determined.

Typically, the invention can be applied to board games in which the role of one or more of the players is taken over by a computer.

Proximity sensors and object presence detectors are used for many different applications. Some of these are touch switches, burglar alarms, identity tags and metal detectors.

There are several varieties of proximity sensors and object detectors. A first type is capable of sensing the presence of an object but cannot distinguish between objects. A typical application of this in a board game may involve, for example, a chess board with a reed switch located beneath each playing square. A magnet is provided within the playing pieces and, as a playing piece is placed on the square, the magnet causes the switch to flip.

A second type of sensor uses a transponder which transmits an identity code back to the sensor thus identifying the object. This type usually involves use of a multi-turn coil and a memory chip which makes the system relatively expensive. Therefore, this is not suitable for use in a board game, for which expense is an important factor.

A third type of system is disclosed in British Patent No. GB-B-2103943. This describes a chess board which contains transmit and receive coils at right angles to each other, with the intersection points defining squares on the board. Each chess piece contains a resonant circuit in its base, comprising a coil wound on a rod core and a capacitor. A pulse of radiation from the transmit coil stimulates a resonant response from any pieces in the row defined by the coil. This "ringing" response is picked up by the intersecting receive coil. Different pieces are

arranged to have different resonant frequencies, so that the frequency of the signal picked up indicates the type of piece whilst the coils involved define the square.

GB-B-2103943 also describes an embodiment in which the same coils are used successively as transmit and receive aerials. First the coil sends a transmit pulse, then the coil is switched by a demultiplexer to pick-up the returned resonant radiation. Therefore, a similar number of switching operations are required (i.e. two switching operations per square), although only one coil is addressed at a time.

A variation on this system is described in EP-B-0360624. Rather than providing a pulse of radiation to stimulate a resonant response, this employs a positive feedback technique whereby a small resonant signal (initiated by noise) is picked up by the receive coil and fed back to the transmitter. Thus the transmitter, receiver and resonant circuit in the piece all oscillate at the piece's particular frequency.

Whilst providing systems which automatically detect the presence and identity of a piece on any of the squares, the systems have a number of disadvantages associated with them.

Firstly, in general both a transmit coil and a receive coil must be addressed in order to detect a piece. In addition, every square must be individually addressed. This requires a complex multiplexer or similar switching device.

Secondly, the resonant circuit in each piece presents a number of limitations: e.g. the number of different pieces which may be detected is limited, since the resonant frequency of the pieces must be spread far enough apart to be differentiated. In addition the resonant frequency of the circuit may vary from the frequency required due to heating up of the ferrite cores of the inductors in the pieces. The system is limited to detecting a unique frequency for each piece, as opposed to other more flexible

(and conventionally expensive) methods such as a memory chip with an identity code.

Thirdly, this system (along with other prior art systems) is only able to detect the identity of one piece on a square at any one time.

According to the present invention, we provide an electronic toy or game playing apparatus comprising one or more transmit aerials associated with a playing region;

one or more playing pieces each containing a transponder and which are movable within the playing region;

an oscillator which provides an input signal to the or each aerial at a predetermined input oscillation frequency;

and means for simultaneously monitoring the power output by the aerial;

wherein each transponder comprises a receive aerial to receive signals from the selected transmit aerial, and a circuit which draws power from the transmit aerial in a variable manner, thereby modulating the power output by the transmit aerial in the same variable manner, whereby the presence of a piece in the playing region can be determined.

The invention is typically employed in a game (such as a board game with a playing piece or pieces). Alternatively, it may be used in a toy (such as an educational toy) in which the presence of an element in a particular region is detected.

Typically, the transponder comprises a digital multivibrator circuit whose power consumption varies with time, i.e. periodically or with a delay time. However, any circuit which provides a variable power response to the transmitted signal may be used.

The invention may be employed in a game with a single aerial associated with the playing region in which the presence of playing pieces is detected. Alternatively, there may be a plurality of discrete playing positions, each with an associated aerial which detects the presence

of a piece in that position. In a further embodiment, there may be one aerial per group of playing positions in the playing region, typically with other overlapping aerials which can detect the presence of a piece on specific positions within the group.

In a preferred embodiment, the variation in power drawn by the transponder on each piece is unique to that piece, allowing the identity of the piece to be determined. This allows the presence and identity of more than one piece in a playing region to be determined.

Typically the game comprises a board game with a number of discrete playing positions on it, for instance chess. Alternatively the game may be an interactive role playing game in which a role is taken by a computer. The game board may be self contained, or may be a peripheral unit which is attached to a PC.

For example, the game may comprise a chess board which comprises an 8 x 8 array of squares. In a preferred embodiment, each row and column has a coil (i.e. aerial) associated with it. Each transmit coil is addressed, allowing the identity of the pieces in each row and column to be determined. Thus, this system allows all 64 squares to be interrogated, with only 16 addressing operations.

The technique used for identifying the objects is a relatively cheap one, but there is a limit to the number of objects which can be distinguished. Applications for this system include electronic toys and other low cost, high volume applications.

Since it is possible to detect pieces at a distance from the transmit aerial, the pieces may be detected in a 3-dimensional game, for instance relative to side walls. Therefore, the present invention is not restricted to the detection of pieces in positions on a surface.

Each item to be detected has a small inexpensive electronic circuit (transponder) attached to it which does not include any kind of power source.

An embodiment of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a block diagram of the system showing one transponder;

Figure 2 is an example of an electronic circuit for the identification oscillator;

Figures 3a and 3b are examples of the output waveforms when one and three playing pieces are present respectively;

Figure 4 is a second type of transponder;

Figure 5A shows a complete circuit diagram for the system;

Figures 5B and 5C are alternative circuits for the transponder;

Figures 6 and 7 illustrate the remaining portions of the array of transmit aerials in the board;

Figure 8a shows the voltage output from transmit oscillator 3 shown in Figures 1 and 5;

Figure 8b shows the current output from the transmit oscillator; and,

Figure 8c shows the output from the power detector shown in Figures 1 and 5.

The purpose of this system is to detect the presence or proximity of one or more specific objects and to distinguish between them. It is capable of detecting and identifying a plurality of objects simultaneously as well as identifying a single object.

The system consists of two parts (illustrated in Figure 1), one of which is a detection system 1 (the sensor) and the other is an electronic circuit 2 (the transponder) which is attached to each item to be detected.

The function of the detection system 1 is twofold. Firstly, it emits electromagnetic radiation which is received by any transponders within a specified distance. Secondly, the detection system is capable of continuously monitoring the emitted power in order to discern any disturbance caused by these transponders.

The function of the electronic circuit 2 attached to each item to be detected (the transponder) is to receive the electromagnetic radiation from the detection system 1, to rectify the received power and use it to run a simple circuit whose power consumption varies with time (which will subsequently be referred to as the identification oscillator).

A block diagram of one possible system is shown in Figure 1. An oscillator 3 generates a continuous (unmodulated) signal and drives one or more transmit aerials 4 via one or more power detectors 5, which continuously monitor power throughput. The transmit aerial 4 may take the form of a single element aerial or, alternatively, an array of aerials which may be driven sequentially or in parallel. Power detector 5 may take the form of one or more current detectors, as the input voltage is a constant alternating signal. A receive aerial 6 provided on each transponder (only one transponder is shown in Figure 1) receives a fraction of the power from transmit aerial 4 and supplies this to a rectifier 7. The rectified output from the rectifier 7 is applied to an identification oscillator or other time dependent circuit 8. If the power is sufficient, the oscillator 8 will oscillate at a frequency much lower than that of the oscillator 3, or produce a finite length time dependent output.

The identification oscillator or time dependent circuit 8 is designed to vary its power consumption as it oscillates or produces its finite length output. A simple oscillator circuit which fulfils this requirement is shown in Figure 2. This is only one of many different possible oscillator circuits. It is a conventional astable multivibrator circuit with the usual collector resistor short circuited (zero Ohms). That is, there is no resistor in the position indicated at 9. This ensures a large variation in power consumption during oscillation.

Figure 4 shows one possible time dependent circuit which produces a single pulse after a predetermined delay time.

The varying power drawn by oscillator 8 may be detected by the power detector 5 in the sensor system, and the proximity of a transponder is confirmed. If each identification oscillator or time dependent circuit 8 is designed to oscillate at a different frequency or deliver a different time delay, power detector 5 will be able to ascertain which frequencies or time delays are present and therefore which specific transponders are in the vicinity of the sensor. To do this, the power detector 5 must be designed to be frequency or delay time selective. Frequency selectivity may be achieved by using a swept or switched frequency bandpass filter or using a logic algorithm. Time delay measurement may be done using a logic counter circuit.

If required, the system may be used for determining the position of one or more transponders by using an array of transmit aerials 4, which may be polled sequentially or simultaneously. One application of this would be an electronic board game, such as chess, where each piece may be identified and its position determined by using an array of 64 square capacitive aerials coincidental with the chess board squares. It may also be appreciated that such a scheme may be simplified by using 16 aerials, each associated with a row or column. In this case, to determine if there is a piece in one particular position, the relevant row and column would be scanned and any transponder frequency which appears in both would be known to be in the square under consideration. There are other ways of scanning such an array which require even fewer aerials. The following description describes a board game application in more detail.

The application example which follows is a detailed description of one possible realisation of this technology for a commercial project. The example is of an intelligent

board game using 100 squares (10 x 10) and 16 different playing pieces. Pieces are identifiable and their positions on the board known even when there is more than one piece on a square.

Figure 5A shows a complete circuit diagram for the system (excluding transmit coils) including a transmit circuit 10. Figures 5B and 5C show respectively the two alternatives of an oscillator playing piece 11 or delay time playing piece 12. (Generally the pieces will only contain either 11 or 12).

Figures 6 and 7 show part of the array of transmit coils which are connected to the circuit 10 in Figure 5A. The array comprises twenty aerials formed by 10 row coils (31-40) and 10 column coils (41-50), each coil having two turns. Each row/column intersection defines a discrete playing position on the board. Each aerial consists of a two turn coil wound around the perimeter of the rectangle formed by the ten squares in the row or column. The aerials may comprise copper wire, or a paper substrate printed with silver loaded ink.

For oscillator 3 a 10MHz oscillator is used 13 which may be derived from the microprocessor clock signal. The signal from the oscillator 8 is applied to multiplexers 14,15 which select one of twenty aerials on the board surface corresponding to the ten rows and columns.

The reason for using coils for aerials 4 is that a large proportion of the electromagnetic field is concentrated inside the coil and there is therefore no danger of the playing pieces responding if placed in an adjacent row or column. Two turn coils are optimum for 10MHz. Capacitive plate aerials may also be used but they are generally less efficient than the coils, particularly as the aerial size increased.

Each of the twenty coils is energized individually, and any playing pieces within the coil area (ten squares), are energized by signals picked up by their own receive aerials. The complete transponders (astable and monostable

types) are indicated at 11 and 12 in Figure 5B and 5C respectively. Each playing piece has a receive aerial 6, capacitor 50 which resonates with an inductor at 10MHz in order to maximise power transfer. This resonant circuit is the same for all playing pieces and has no bearing on the playing piece identity. In addition, the high frequency resonant circuit does not require an inductor with a high number of turns and a ferrite core, as in the prior art resonant pieces. Therefore, it is less susceptible to temperature changes.

Diodes 52-55 rectify the received signal to provide DC power for the astable multivibrator 11, which is then able to oscillate. Bias resistors 56-58 are chosen to ensure that the oscillation frequency is relatively independent of the supply voltage. Capacitors 20,21 are equal, but different values are used for each playing piece. When transistor 60 is conducting, the transistor 61 is switched off, the playing piece draws more power from its aerial 6 and thus also from transmit aerial 4. This is measured by including a series resistor 62 to sample the current in the transmit aerial 4. The voltage signal before the resistor is unmodulated, and therefore remains at the fixed oscillator frequency. However, the current (and hence power) is modulated by the presence of a piece. After the series resistor, the voltage is modulated, and this is detected by diode 63 and amplified to logic levels by power detector 64.

Figures 8a-8c show graphs of voltage and current envelopes against time for the signals in the transmit circuit 10. The voltage output from the oscillator 13 is shown in Figure 8a. This shows the voltage variation to the left of the resistor 62. It is an unmodulated 10MHz signal. Figure 8b (not to scale) shows the envelope of the modulated current signal from the oscillator 13. The voltage on the right hand side of 62 will be modulated in a similar manner to the current signal (due to the resistor 62), resulting in an output from the power detector 64 as

shown in Figure 8c. The resulting waveform is a continuous series of narrow pulses (see Figure 3a). If more than one playing piece is present in the row or column under scrutiny, two or more pulse trains will be superimposed in the resulting waveform (see Figure 3b indicating the situation with three playing pieces). The pieces may be identified by analysing the waveform, using hardware or software. In the hardware option, a swept or programmable bandpass filter may be used to differentiate between pieces. The software alternative would scan the waveform looking for different known pulse repetition frequencies.

An alternative playing piece circuit is shown in Figure 4 and Figure 5C. Power is transferred to the playing piece in the same way as described above. This produces a single pulse after a delay which is different for each piece. This circuit is a monostable, or "one shot" multivibrator. The delay starts immediately after the receive aerial 6 is energized and is relatively independent of the supply voltage. This system is more suited to software detection of multiple pieces. After energization of each piece in the transmit coil 4, a finite series of narrow pulses will be detected, each playing piece being identifiable by the unique delay time associated with its single pulse.

Once all twenty coils have been energized in turn, it is possible for software to determine which playing pieces are in each square by looking for rows and columns which contain the same piece or pieces. It should be noted that this procedure is quicker than scanning individual squares (as in British Patent No. 2103943 and European Patent No. 0360624) as there are only twenty measurements to be made, rather than a hundred. This is one advantage of working with a system which uses the same aerial to transmit and receive. Another advantage of this system, is that it is possible to detect and correctly identify a plurality of playing pieces on one square.

CLAIMS

1. Electronic toy or game playing apparatus comprising one or more transmit aerials associated with a playing region;

one or more playing pieces each containing a transponder and which are movable within the playing region;

an oscillator which provides an input signal to the or each aerial at a predetermined input oscillation frequency;

and means for simultaneously monitoring the power output by the aerial;

wherein each transponder comprises a receive aerial to receive signals from the selected transmit aerial, and a circuit which draws power from the transmit aerial in a variable manner, thereby modulating the power output by the transmit aerial in the same variable manner, whereby the presence of a piece in the playing region can be determined.

2. Apparatus according to claim 1, wherein each transponder draws power from the transmit aerial in a characteristic variable manner, further comprising means for detecting the characteristic whereby the identity of the piece can be determined.

3. Apparatus according to claim 1 or claim 2, wherein the transponder comprises a digital multivibrator circuit whose power consumption varies with time.

4. Apparatus according to claim 3, wherein the multivibrator comprises an astable multivibrator whose power consumption varies periodically at a characteristic frequency.

5. Apparatus according to claim 3, wherein the multivibrator comprises a monostable multivibrator whose power consumption varies with a characteristic time delay.

6. Apparatus according to claim 4 or 5, wherein the characteristic varies over a time scale substantially greater than the period of the predetermined input oscillation frequency.

7. Apparatus according to any of the preceding claims, comprising an array of transmit aerials, each defining a portion of the playing region, further comprising means to select a transmit aerial, whereby the presence of a piece in each portion of the playing region can be detected.

8. Apparatus according to claim 7, wherein each portion comprises a group of discrete playing positions, and the aerials overlap whereby the presence of a piece in each discrete playing position can be determined.

Fig.1.

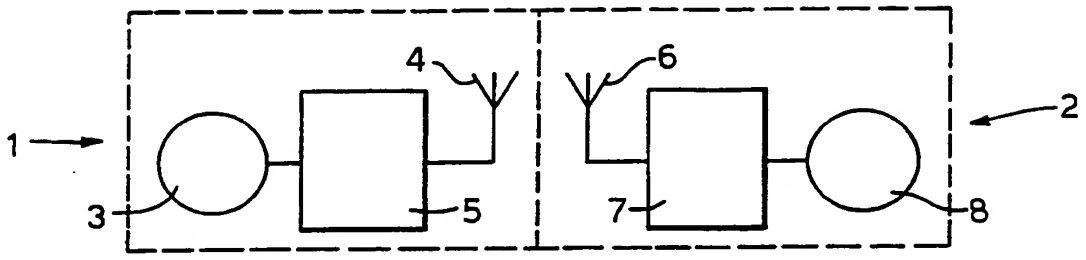


Fig.2.

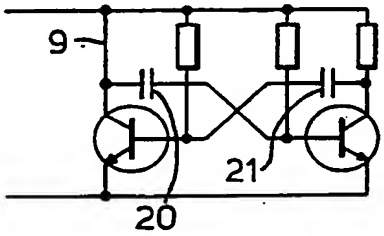


Fig.3a.

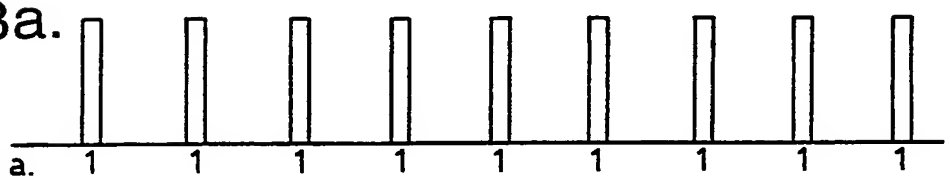


Fig.3b.

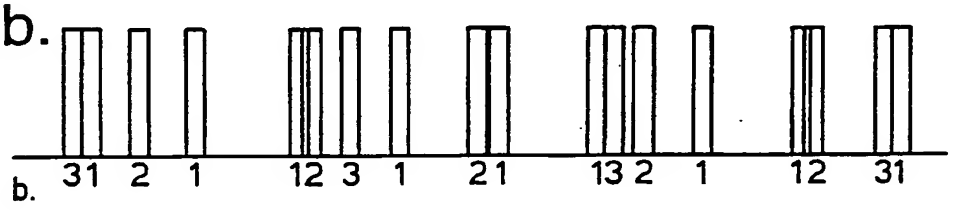


Fig.4.

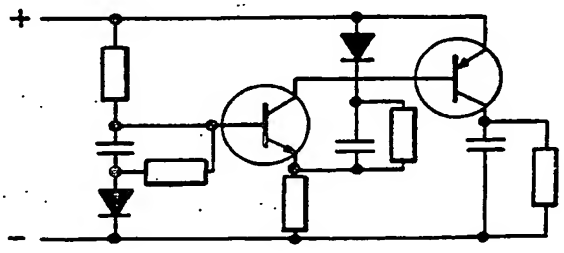


Fig.5.

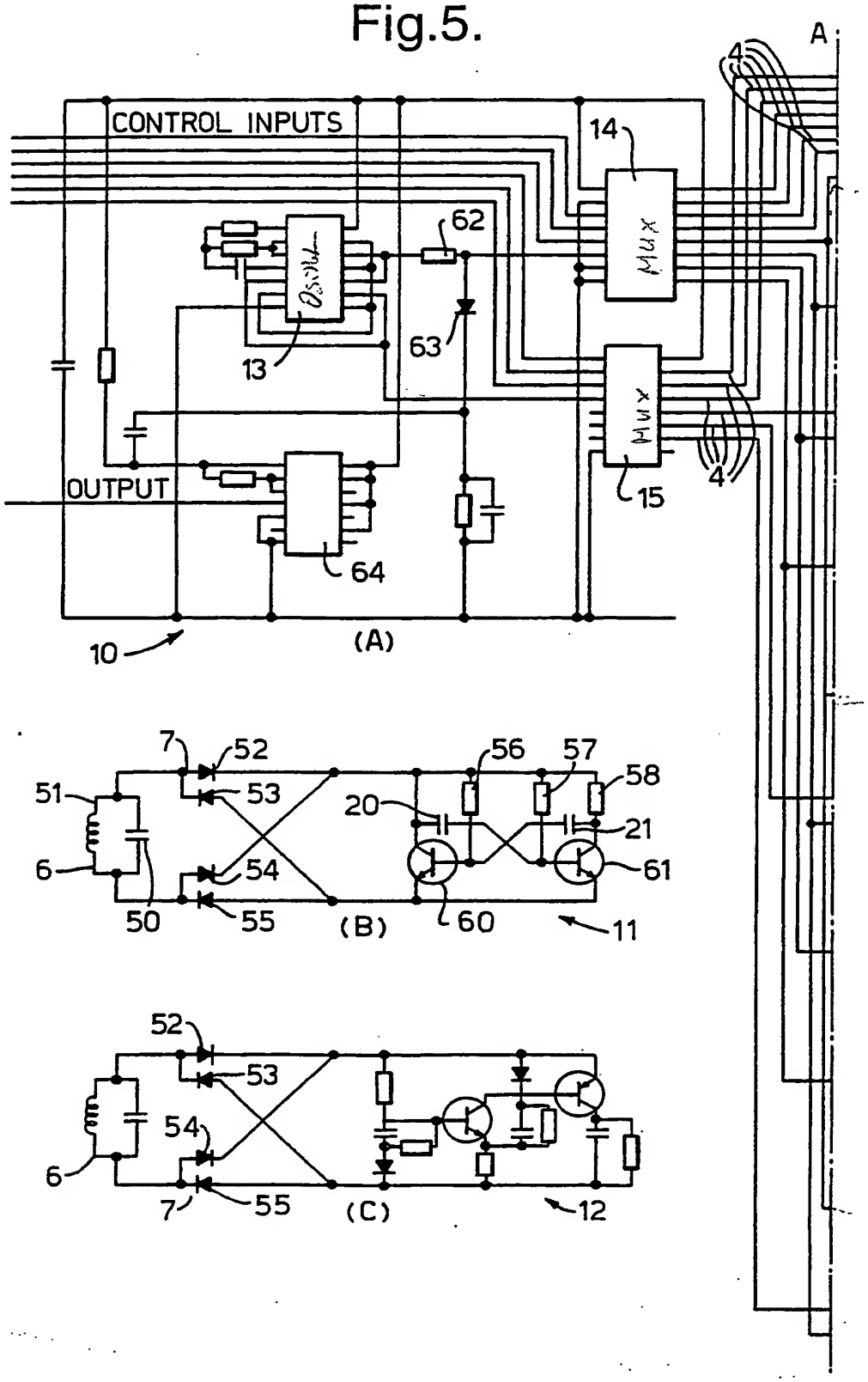


Fig.6.

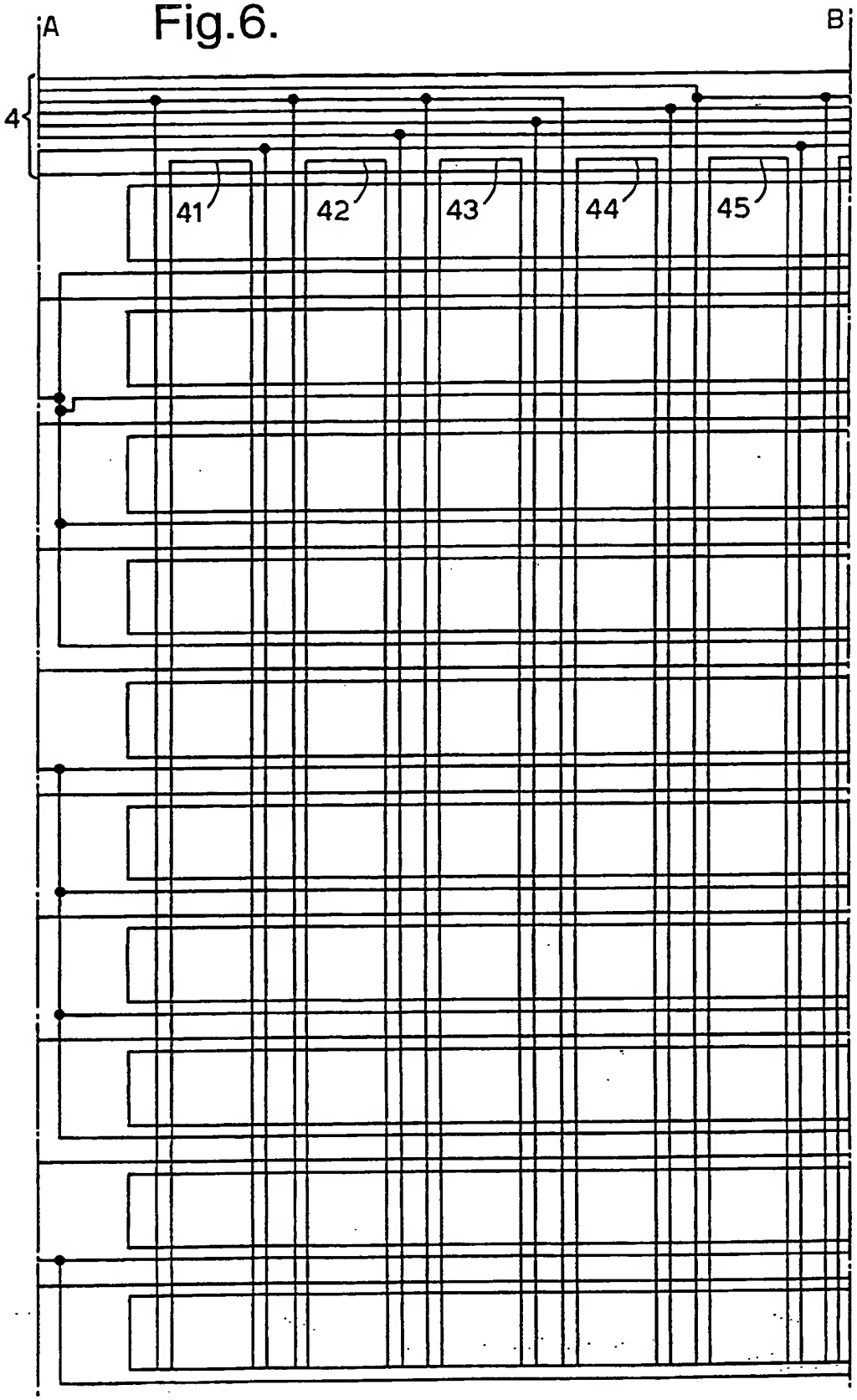


Fig.7.

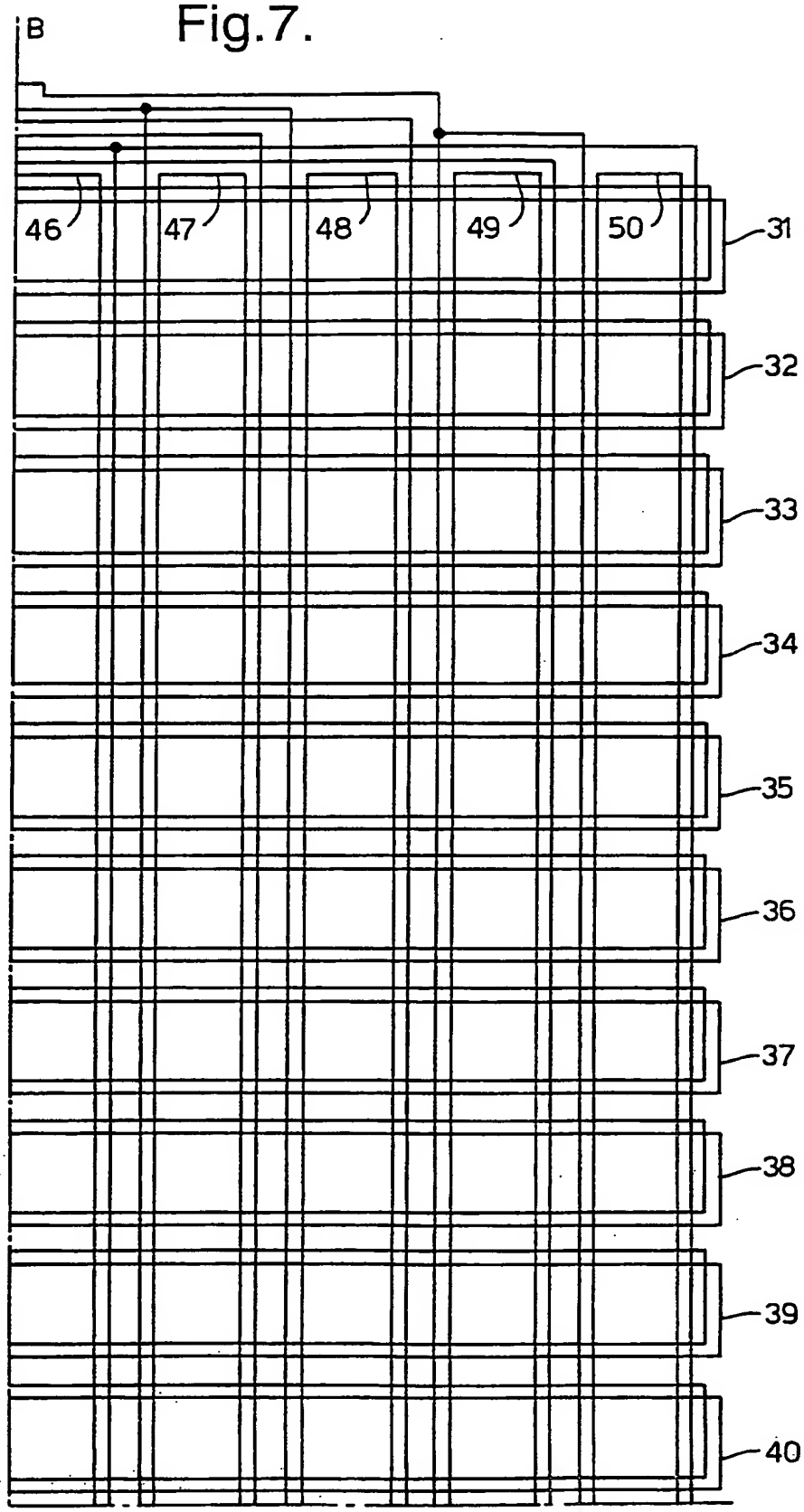


Fig.8a

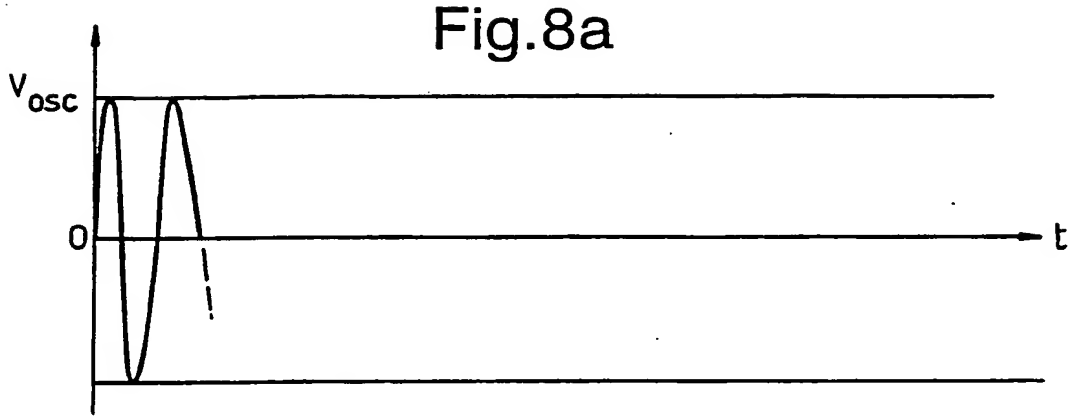


Fig.8b

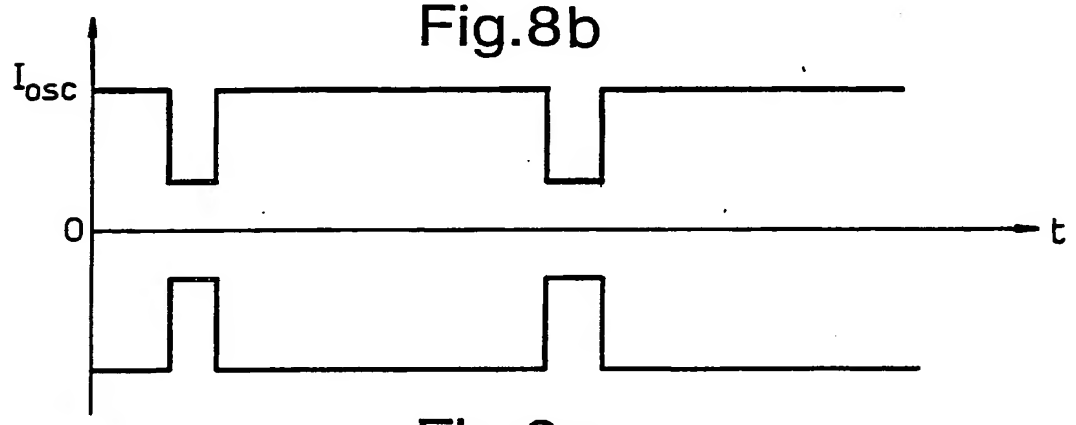
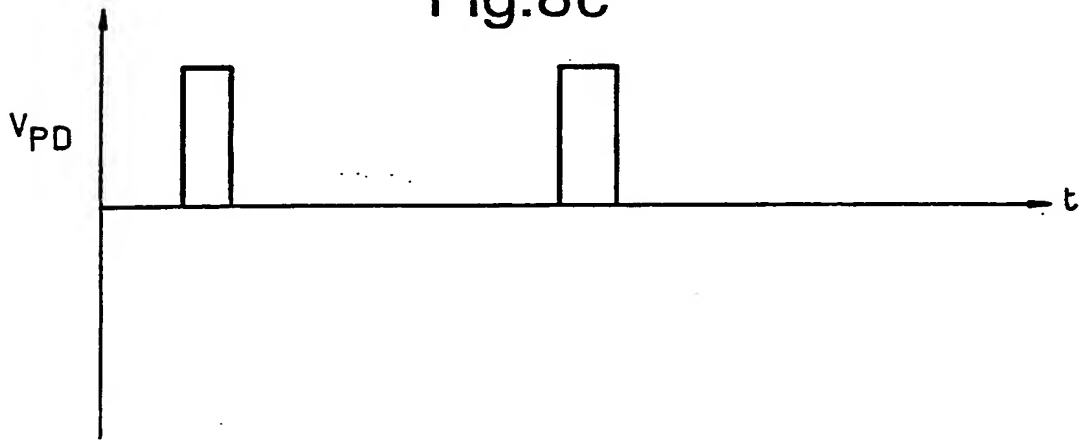


Fig.8c



INTERNATIONAL SEARCH REPORT

Inter. al Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A63F3/02 G06F161/00 G01S13/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A63F G06F G01S A63B G07F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB,A,2 267 222 (WALKER) 1 December 1993 see page 4, paragraph 6 - page 5, paragraph 4	1
A	US,A,3 984 109 (WILES) 5 October 1976 see column 2, line 44 - line 47	1
A	EP,A,0 360 624 (SAITEK LTD) 28 March 1990 cited in the application see claim 1	1
A	WO,A,91 13655 (IPU INT.PATENTS UTILIZATION LTD) 19 September 1991 see page 8, paragraph 2	1
A	US,A,5 086 390 (MATTHEWS) 4 February 1992 see column 2, line 64 - column 3, line 6	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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1

Date of the actual completion of the international search	Date of mailing of the international search report
30 June 1995	13.07.95

Name and mailing address of the ISA	Authorized officer
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 534 712 (HUGHES AIRCRAFT COMPANY) 31 March 1993 see page 3, line 38 - line 42 ---	1
A	EP,A,0 436 497 (TREND PLASTICS, INC.) 10 July 1991 see claim 9 -----	1

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Information on patent family members

Inten al Application No
PCT/GB 95/00771

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
GB-A-2267222	01-12-93	NONE		
US-A-3984109	05-10-76	NONE		
EP-A-0360624	28-03-90	AU-A-	6630190	31-05-91
		WO-A-	9106352	16-05-91
		JP-T-	4506920	03-12-92
		US-A-	5188368	23-02-93
WO-A-9113655	19-09-91	DE-A-	4007454	12-09-91
		AT-T-	116143	15-01-95
		AU-B-	650643	30-06-94
		AU-A-	7442591	10-10-91
		DE-D-	59104078	09-02-95
		EP-A-	0518913	23-12-92
		ES-T-	2068572	16-04-95
		JP-T-	5505120	05-08-93
		US-A-	5423549	13-06-95
US-A-5086390	04-02-92	NONE		
EP-A-0534712	31-03-93	CA-A-	2075122	24-03-93
		JP-A-	6218136	09-08-94
		US-A-	5382026	17-01-95
EP-A-0436497	10-07-91	US-A-	5166502	24-11-92